Wake flow characteristics at high wind speed - DTU Orbit (08/11/2017)

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Wake flow characteristic at high wind speeds is the main subject of this paper. Although the wake losses decrease at high wind speeds it has been found in a recent study that for multiple wake inflow the increase in loading due to wake effects are substantial even at wind speeds well above rated power. In the present study we simulate the wake flow for a row of turbines with the wind aligned with the row using a simplified approach. The velocity deficit, being a function of the thrust coefficient, is simulated based on the BEM solution for wake expansion. An axis-symmetric boundary layer equation model (the same as implemented in the DWM model) is subsequently used to develop the deficit down to the next turbine, and then the approach is successively repeated. Simulation results for four different spacing's in a row with eight turbines show that there are two major flow regimes. In the first flow regime comprising the first turbines in a row the local mean wind speed over the rotor disc is found to decrease linearly from turbine to turbine for the turbines operating at maximum power but also to some extend extend below rated power. The second flow regime is characterized by a constant local equilibrium wind speed. Based on the present results the equilibrium wind speed normalized with the inflow wind speed varies from about 0.4 for a spacing of 3D to slightly above 0.6 for a 9D spacing at an ambient turbulence intensity equal 6%. It is also found that for a turbine in the intersection region between the two flow regimes a strong variation in power and thrust occur, e.g. going from almost zero power to rated power for a wind speed change of 4m/s. Another result is that the inflow profile to the last turbine in the row at a wind speed of 16m/s for a spacing of 3D shows a variation over the profile from around 3m/s to 16m/s, which explains the high loading observed at high wind. Two models for merging wakes are tested, and one works best below rated power and another shows excellent performance around 14m/s. Finally, power measurements from the Lillgrund wind farm in a row with a 4.3D spacing and for wind speeds from 8-14m/s are used to validate the modeling setup.

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